NAL PROPOSAL No. 0157

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A PROPOSAL TO STUDY HIGH ENERGY DIFFRACTIVE N* PRODUCTION

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ABSTRACT

We propose to study diffraction dissociation of the nucleon by operating the 30-in. bubble chamber at NAL in a triggered mode. In order to obtain an enriched sample of N^* production, we plan to set up a triggering scheme whereby the mass recoiling against the fast forward particle is used in the decision of whether or not to take a picture. Specifically we plan to do a partial-wave analysis of the N^* system in order to test the various selection rules for diffractive processes. We propose to do this experiment using 50 GeV/c incident π^- particles.

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CONTENTS

I. INTRODUCTION

We propose to study diffractive dissociation of the target nucleon in a $\pi^- p$ experiment at 50 GeV/c by triggering the 30-in. hydrogen bubble chamber. Specifically the reaction we will study is

$$\pi^- p \to \pi^- N^* \tag{I-1}$$

where the N^* decays strongly into πN or $\pi\pi N$. The reason for choosing an incident energy of 50 GeV/c will be discussed somewhat in this proposal. Essentially it represents a happy medium between going to a high enough energy where diffraction dissociation becomes more dominant relative to any other single inelastic processes yet low enough so that the required resolution and acceptance can be obtained with a relatively modest setup. The proposed experiment involves using the mass of the system of particles recoiling against the fast forward π^- particle in the decision of whether or not to take a picture. The experiment we propose here is very similar to one already being carried out by this group at SLAC using the 40-in. bubble chamber exposed to a beam of 14 GeV/c π^- particles.

The specific goal of this experiment is to analyze the spin structure of the produced N^* system to test out various selection rules which have been conjectured for these diffractive processes and to compare these results with those of the lower energy experiment. In particular we will be able to check to what extent the diffractive processes stay constant with increasing energy.

The goals of this experiment could be met with $\sim 4.5 \times 10^6$ expansions of the 30-in. bubble chamber yielding an effective exposure size of $\sim$ 80 ev/μb.

This should require about 3 months of running time. We expect that our trigger will yield about 300K pictures which could be analyzed by the combined measuring facilities of the two institutions represented in this group in about 6-9 months. The equipment necessary to do the experiment (excluding the spectrometer magnet) already exists and could be moved to and set up at NAL with a minimum of effort.

The above exposure size matches that of the experiment currently being carried out at SLAC. It represents what we feel is an exposure which provides the statistical sensitivity to determine the selection rules. The results of the analysis of the present experiment, which should be available a year from now, should determine whether one might increase or reduce the size of the requested exposure.

II. PHYSICS JUSTIFICATION

Experimental studies of quasi-two-body processes at present energies show that there exist a class of reactions which show the following strong characteristics (refer to Figure 1):

1) the reactions occur with relatively large cross sections ($\sim$ 1 mb);
2) the cross sections appear to remain constant with increasing energy;
3) the cross sections show a strong exponential t behavior ($d\sigma/dt \sim e^{-At}$ where A is on the order of 10-4 $(GeV/c)^{-2}$);
4) the internal quantum numbers (e.g., baryon number, g-parity, I-spin) of particle a(b) are the same as those of c(d).

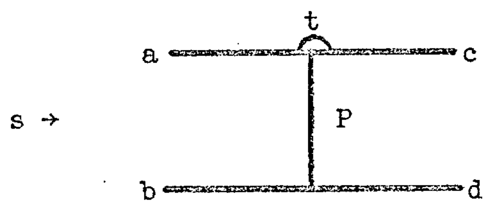


FIGURE 1

These processes, whose characteristics are similar to those of elastic scattering, are thought to proceed through Pomeron (0 quantum number exchange) exchange. They are referred to as diffractive processes. Examples of diffractive dissociation of the beam particle are the reactions

$$\pi p \to A_1 p \qquad \text{(II-1)}$$

and

$$\gamma p \to \rho^o p \qquad \text{(II-2)}$$

Our proposal is to study diffraction dissociation of the target particle giving rise to N^* ($I = \frac{1}{2}$) production.

The experimental and theoretical picture of diffractive processes is still quite unclear. Several selection rules, in addition to the internal quantum number selection rules, have been proposed. Morrison[1)] has suggested the empirical rule

$$\Delta P = (-1)^{\Delta J} \tag{II-3}$$

where ΔP and ΔJ are the change in the parity and spin between the produced and initial dissociating particle. In our case this would be the N^* and the proton respectively. Chou and Yang[2)] have suggested that if the product of the parities of the incoming and outgoing particles is odd, the cross section for scattering at t=0 is zero. Carlitz, Frautschi and Zweig have included in the list of internal quantum number selection rules the conjecture that the SU(6) character[3)] is also preserved in diffraction scattering.

There have also been suggestions that there are selection rules which restrict the change in spin direction between initial and final particles, where by initial here we mean the dissociating particle and the final particle is the produced particle. For example, a study of ρ^o photoproduction[4)] indicates that s-channel helicity is conserved. That is, in this example of diffractive scattering, the spin projection along the direction of motion of the initial and final particle is preserved. However a recent study of A_1 production indicates that it is t-channel helicity which is conserved[5)]. In this case the projection along the initial particle direction in the Gottfried-Jackson frame[6)] is conserved. The corresponding tests for N^* production have not yet been made.

In order to study and test these various conjectures for reaction (I-1) what is necessary is a systematic high statistics study of the spin composition of the produced N^* system[7]. Up to now, the data which allow one to look at the decays of the produced N^* are bare bubble chamber experiments which suffer from very low statistics (2-3 ev/μb). On the other hand the high statistics missing mass experiments[8], while providing information on the energy and t-dependence of N^* production do not allow one to study the spin composition of the N^* system.

The group proposing this experiment is presently engaged in a similar one at the Stanford Linear Accelerator Center. The goal of that experiment is to obtain a high statistics sample of bubble chamber photographs of diffractive scattering, thus allowing a study of the decay characteristics of the N^*. In order to keep the number of photographs small while taking an effectively large exposure (300K pictures, 100 ev/μb) the 40-in. chamber at SLAC is being operated in a triggered mode. The energy of the incident π^- beam in that experiment is 14 GeV/c.

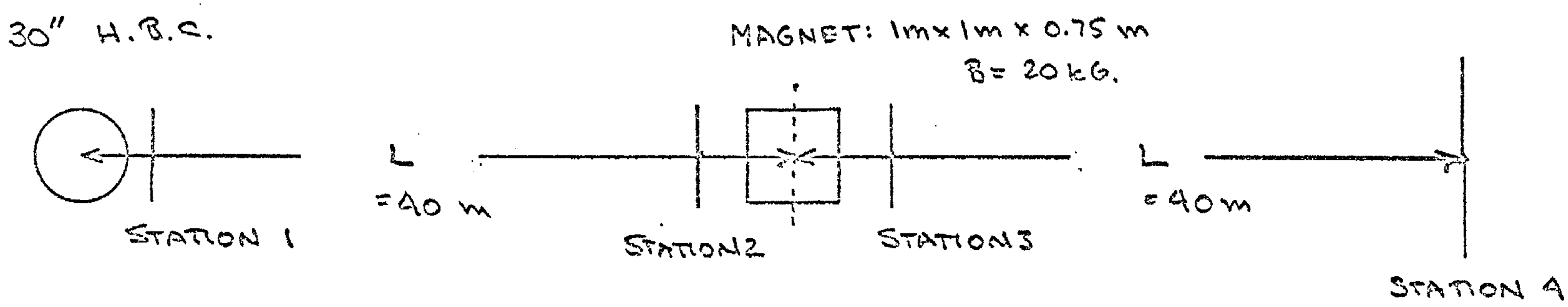
Motivation for going to the highest energy (consistent with good resolution and acceptance using present equipment) is very strong. The present diffractive data indicate that gross features remain unchanged with energy. A comparison of the lower energy detailed spin analysis with a similar study at significantly higher energy would thus be valuable. Another point has to do with the contribution of the OPE amplitude at lower energies. The OPE contribution complicates somewhat the spin analysis in the lower energy experiment[7]. At an energy of 50 GeV/c, the contribution of this amplitude relative to diffractive scattering is down by a factor of 10 compared with the lower energy (14 GeV/c case) owing to the p_{LAB}^{-2} fall-off of the OPE amplitude. Moreover, as the overall center of mass energy increases, the kinematics separate OPE reactions like $\pi N \to \rho N$ and $\pi N \to \rho\Delta$ from the two and four prongs, respectively, resulting from diffractive N^* production.

III. EXPERIMENTAL METHOD

A. Introduction

The characteristics of N^* diffraction dissociation production lead to the following laboratory kinematics: a very fast forward-going beam-like particle and a low momentum N^* decaying into low momentum secondaries with no preferred direction in the LAB. Thus measurement of the fast forward particle, with good momentum resolution is best done with a small aperture spectrometer whereas the bubble chamber is an excellent tool with which to detect and measure the low momentum secondaries from the N^* decay. The experimental layout we propose is shown in Figure 2. This design is very similar to that of an experiment already being carried out by this group at SLAC using the 40-in. bubble chamber in a triggered mode. The goals of that experiment are to look at diffractive N^* production at 14 GeV/c. (Performance characteristics of that experimental setup are listed in Appendix B.) The experimental layout shown in Figure 2 consists of the Argonne 30-in. bubble chamber and a magnet which is 1m long with a .75m x 1m aperture with a B•dL of 20 kG-m. We have chosen these magnet parameters which we feel represent a relatively modest magnet which can provide the momentum resolution required in this experiment.

The four measuring stations, as shown in Figure 2, each consist of wire planes. The sparks in the planes are read out using magnetostrictive wands. The positions of sparks along a track are read into an on-line computer which computes the missing mass recoiling against the fast forward particle (a π^- in this case). If the recoil mass is of interest, the bubble chamber lights will be fired and a picture taken. A counter array will be



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PROSED LAYOUT OF HYBRID SYSTEM TO STUDY N* PRODUCTION		
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CHECKED BY	SCALE	
APPROVED BY	W.O.	

FIGURE 2.

used, composed very likely of proportional counters, to determine whether or not to fire the high voltage on the wire planes. This fast logic will require that one and only one charged particle be in the forward direction and that that particle is not the beam particle.

B. Beam

It has been indicated that the Argonne 30-in. chamber will be used in the high energy hadron beam in the neutrino area at NAL. Inasmuch as the 30-in. will have already been operated in an experimental program to do a variety of experiments with p, π^+, and π^- beams, we assume that beam tuning detectors, and a Cerenkov counter to separate π's from K's and protons will already exist. Furthermore we assume a beam spill of about 500 μsec duration with about 15 particles/spill and up to 3 spills/accelerator pulse. The required momentum resolution on our π^- beam is $\Delta p/p = 0.1\%$.

C. Bubble Chamber

The main features of the 30-in. bubble chamber are:

a) high resolution dark-field optics;

b) horizontal magnetic field of 32 kG;

c) capability of pulsing at up to 5 expansions/sec;

d) 2.5" x 7" beam entrance window;

e) 5" x 20" exit window, the bubble chamber window is .12" Fe and the vacuum tank windows .25" Al;

f) horizontal and vertical exit angles of $\pm 3.5^\circ$ and $\pm 10^\circ$, respectively, set by the bubble chamber magnet aperture;

g) typical flash delay (for optimal bubble growth) of about 2 msec.

This chamber should provide good momentum measurement of the low momentum secondaries from the N^* decay.

D. Spectrometer

The downstream spectrometer will consist of 4 measuring stations, a magnet, readout electronics and an on-line computer. All these components, with the exception of the magnet, exist and are presently in use in our SLAC experiment.

Station 1 (refer to Figure 2) is located directly behind the bubble chamber magnet. It consists of a pair of adjacent x-planes, for redundancy, and a pair of y-planes. Also included are a pair of u-planes and a pair of v-planes, again pairs for redundancy, which are othogonal to each other and rotated 45° with respect to the x,y planes. These u,v planes are used by the off-line reconstruction programs to resolve ambiguities in associating sparks along a track. Station 2 is located 40m downstream of Station 1 and in front of the spectrometer magnet. Directly behind (downstream) of the magnet is Station 3. Both Stations 2 and 3 are similar; each consists of a pair of x and a pair of y planes. The last station is located 40m downstream of Station 3. This station consists of 4 x planes and 4 y planes, separated into pairs and placed side by side to provide necessary coverage of the solid angle of particles emerging from the spectrometer magnet. The 40m lever arm is set by the resolution required by our trigger. This is discussed in Section III-E.

Each of the planes mentioned above is 1m x 1m in dimension. Positions of sparks are read off by a magnetostrictive wand on each plane. The scalars can store up to 4 sparks per plane (per wand) including the fiducial pulse. The spark chamber electronics are already interfaced to the on-line computer, which is a Sigma-2.

The magnet requirements are a magnet with a horizontal magnetic field (this alignment providing maximum acceptance) with a 1m x .5m aperture and a B•dL of 20 kG-m. We feel that these requirements are modest. Such a magnet might be already available.

The fast on-line analysis and data logging is done on a Sigma-2 computer. The configuration for this system is:

a) 32K words core memory with the last 4K having an external port;

b) random access disk with a .75M byte capacity;

c) 2 7-track tape drives;

d) 400 cpm card reader;

e) 250 lpm line printer;

f) CRT display with vector and character generator;

g) 16 priority interrupts;

h) interface to electronics for 12 wire chambers.

A fast on-line program reconstructs the trajectory of the forward particle in the plane of bend of the magnet, in this case the vertical plane. The momentum of the particle is thus measured and its recoil mass calculated. This mass is used in the decision of whether or not to fire the camera lights and take a picture. The essential thing here is that the time for reading in the data and doing the reconstruction and calculations be less than the maximum time allowed for bubble growth. For this chamber that time limitation is 2 msec. In our SLAC experiment, the time required to make the decision of whether or not to flash the lights was < 2 msec for 98% of the cases. Off-line programs in the Sigma-2 do a more complete track reconstruction using both vertical and horizontal information. Various experimental parameters, such as missing mass, chamber efficiencies, trigger rates can be monitored and histograms of interesting quantities displayed on the display CRT while the experiment is in progress.

E. Triggering and Mass Resolution

Since elastic scattering, which has about 5 times the cross section of diffraction dissociation, also gives rise to a fast forward beam-like particle, it will be desirable to select against these scatters in order to get an enriched sample of diffractive scattering. This requires that the mass resolution in the elastic region be of the order of the pion mass, 140 MeV, in order to separate the elastic peak from threshold for single pion production. In light of this the lever arm of the spectrometer is set by this resolution requirement. Figure 3 shows the various contributions of the missing mass errors in the elastic region from uncertainties in the angle and momentum measurement of the fast forward as well as the uncertainty in the beam momentum as a function of lever arm. We have assumed a negligible contribution to the mass uncertainty from multiple scattering. This is true, of course, only if provisions are made to provide a helium bag in the forward spectrometer. Otherwise this contribution is non-negligible and precludes the possibility of obtaining adequate mass resolution. As can be seen, the most significant contribution in the region of smaller lever arms comes from the uncertainty in the momentum determination of the fast forward. We have chosen to operate at $L = 40$m where $\delta M \sim 100$ MeV. We have assumed a magnet B·dL of 20 kG-m. and a positional accuracy of the spark chambers of 0.5mm (see Appendix B). For the curve shown we have taken $t = -0.2$. As

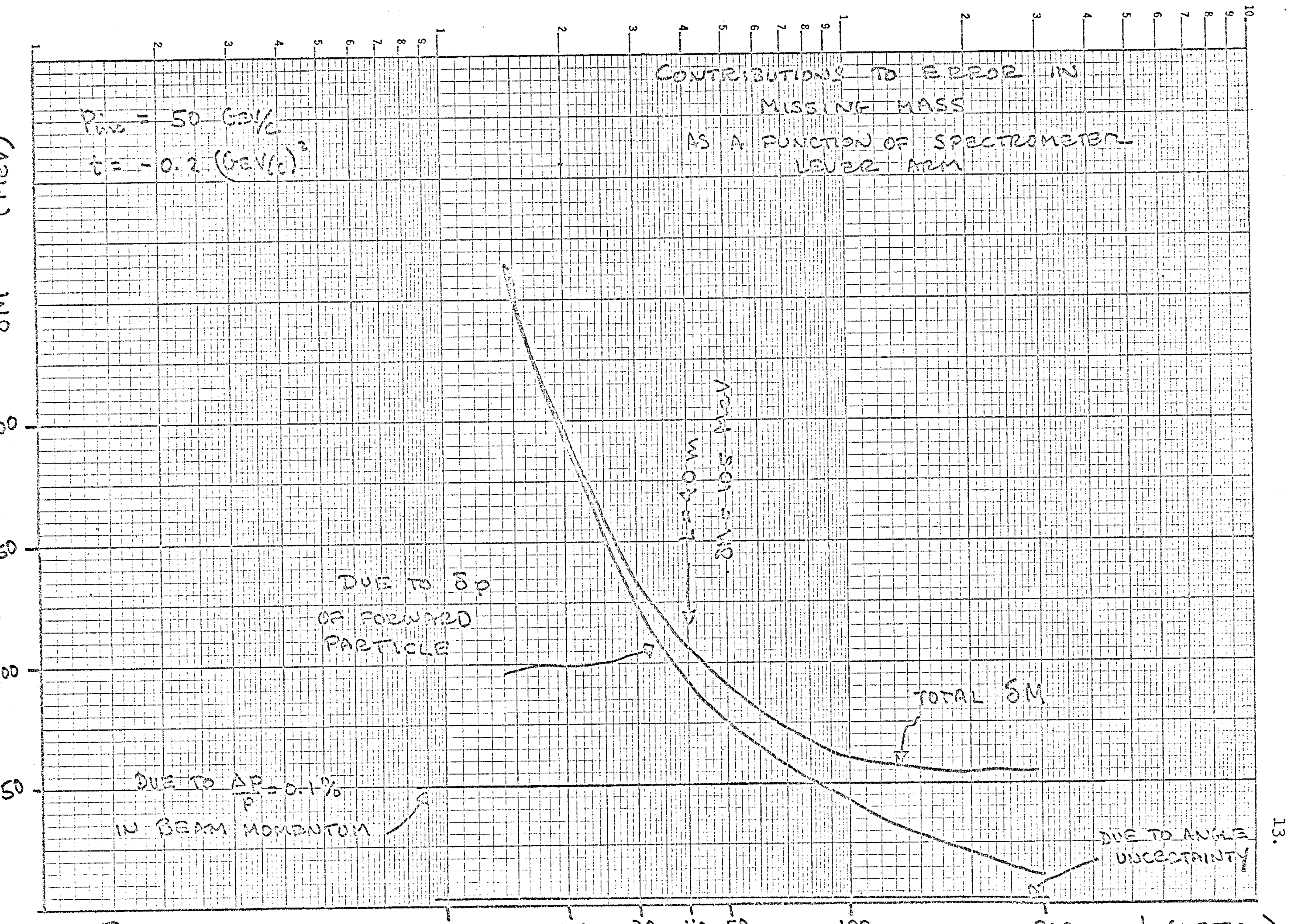
CONTRIBUTIONS TO ERROR IN
MISSING MASS
AS A FUNCTION OF SPECTROMETER
LEVER ARM
P_{inc} = 50 GeV/c
t = - 0.2 (GeV/c)^2
DUE TO δp
OF FORWARD
PARTICLE
TOTAL δM
DUE TO $\frac{\Delta P}{P}$ = 0.1%
IN BEAM MOMENTUM
DUE TO ANGLE
UNCERTAINTY
L (METERS)
10
20
30
40
50
100
300
50
100
150
200

FIGURE 7.

shown in Appendix A, this resolution is not sensitive to small changes in t at these energies.

F. <u>Expected Trigger Rates</u>

In calculating the trigger rates we have assumed the following:

a) the full 30-in. volume of the hydrogen in the chamber is effective target;

b) the bubble chamber window and the vacuum tank window provide another 6" of effective hydrogen target;

c) 15 π^-/pulse into the chamber;

d) an efficiency, as a function of t, as shown in Figure 4.

The efficiency function, shown in Figure 4, assumes a uniform distribution in N^* masses from about 1.1 to 5.0 GeV. The fall-off in efficiency at higher t is due to the angular acceptance of the spectrometer magnet. This is the limiting factor in our t-acceptance at 50 GeV/c. The effect of the efficiency function on typical diffractive t-distributions ($d\sigma/dt \sim e^{-8t}$ and e^{-4t}) is shown in Figure 5 where we give the integrated percentage of the total diffractive cross section as a function of t, with and without folding in of the efficiencies. We see that for the part of the diffractive process which varies like e^{-8t} the geometric acceptance is about 90%. This corresponds mainly to the N^*_{1400} region. According to a recent missing mass counter experiment, the diffractive cross section has a t-dependence of e^{-4t} for $M_{N^*} > 1500$ GeV. Our geometric acceptance here is about 70%. With 15 tracks into the 30-in. chamber we expect about 1 π^-p interaction/expansion. According to Reference 8) we expect about 1.5 mb of cross section in the N^* region of interest. Since the total π^-p cross section is 25 mb we might

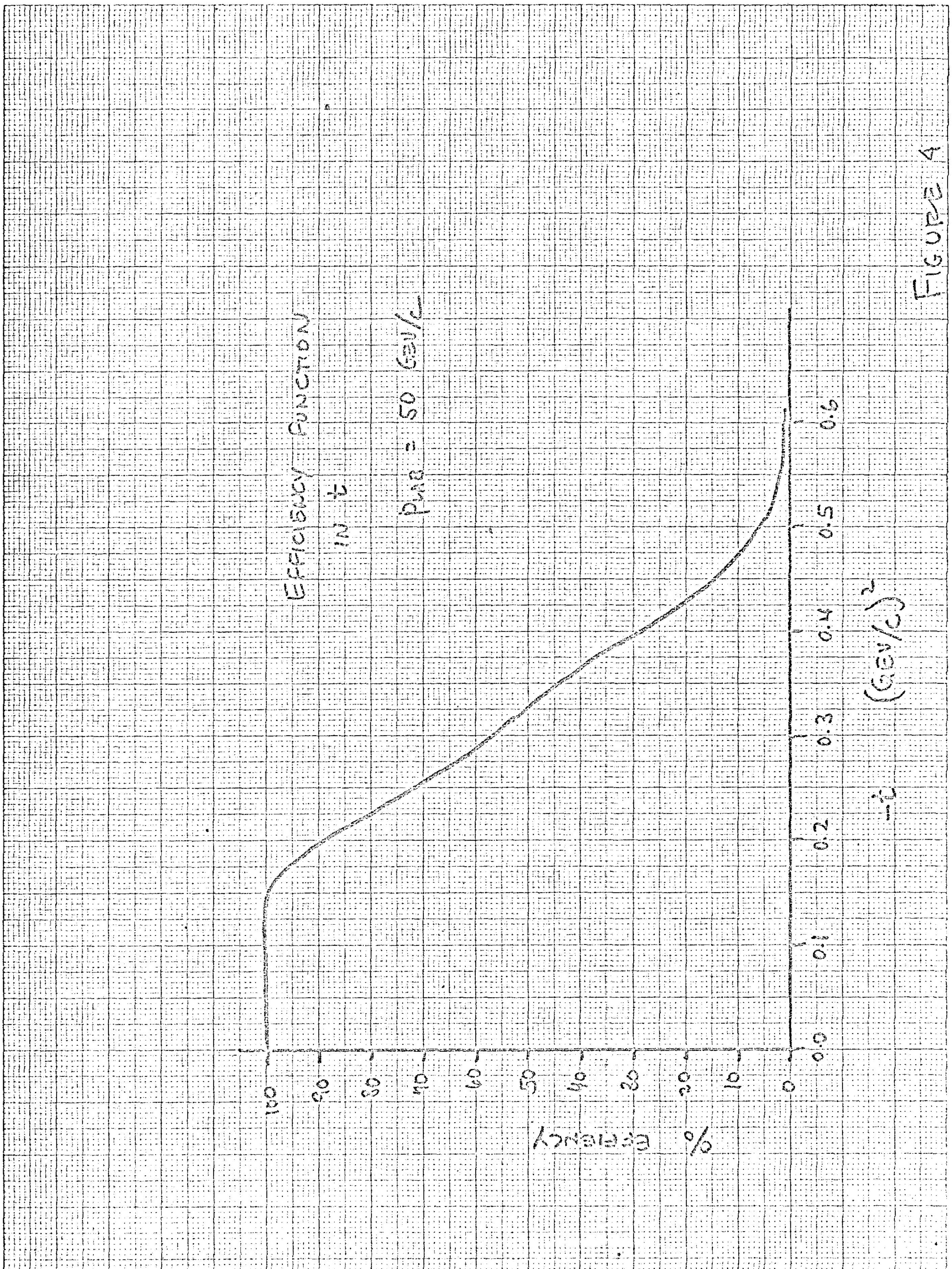
EFFICIENCY FUNCTION
IN t
PLAB = 50 GeV/c
% EFFICIENCY
100
90
80
70
60
50
40
30
20
10
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
-t (GeV/c)²

FIGURE 4

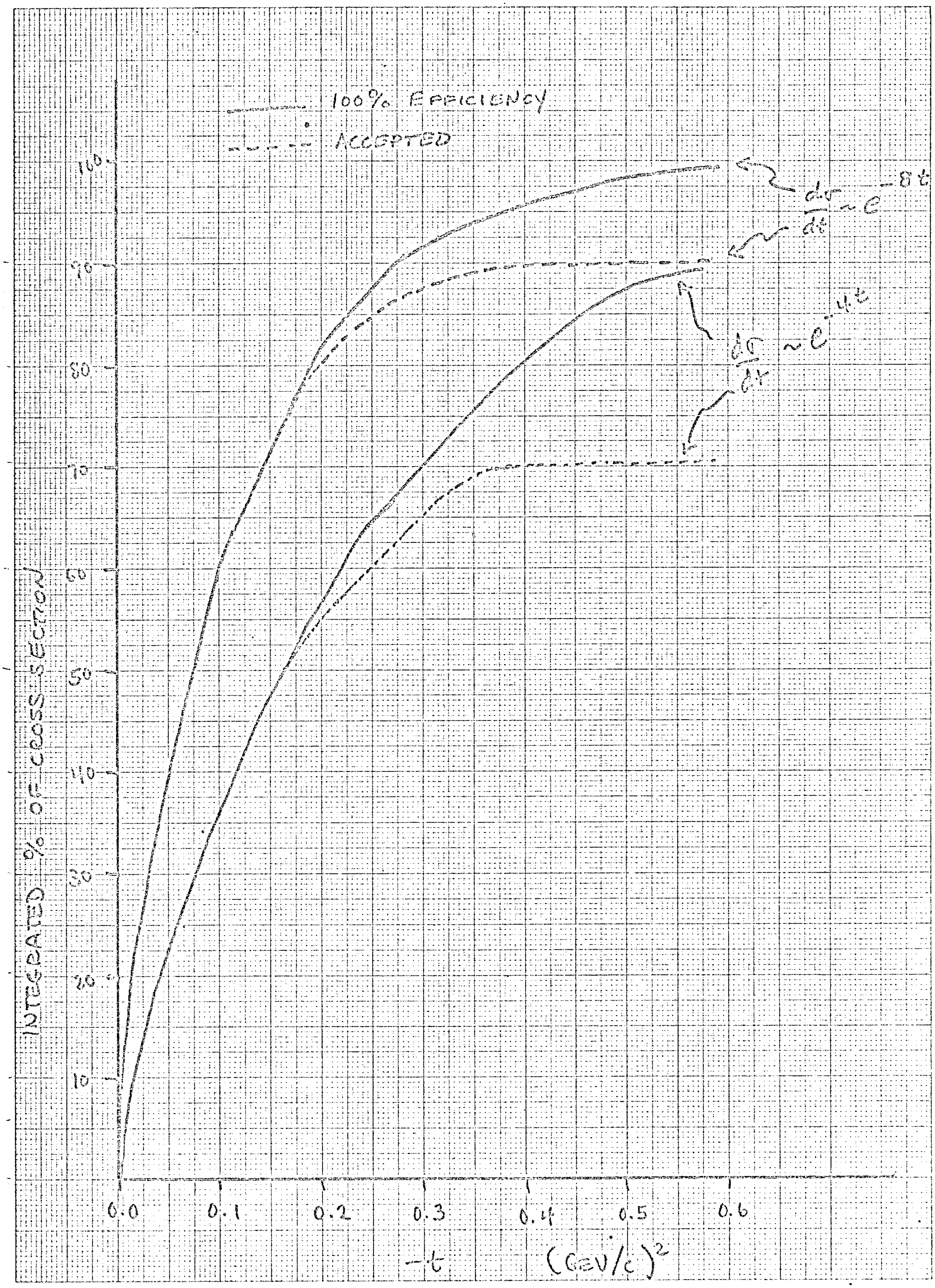
100% EFFICIENCY
ACCEPTED
$\frac{d\sigma}{dt} \sim e^{-8t}$
$\frac{d\sigma}{dt} \sim e^{-4t}$
INTEGRATED % OF CROSS SECTION
100
90
80
70
60
50
40
30
20
10
0.0
0.1
0.2
0.3
0.4
0.5
0.6
$-t$ $(GeV/c)^2$

FIGURE 5

expect to take a picture every 20 bubble chamber expansions. However, the following must be folded in:

a) an overall geometrical efficiency of 70%;

b) false triggers due, for example, to $\pi^- \to \mu^- \nu$ decays of the beam where the μ^- has the right momentum to look like a triggering particle;

c) some contamination from elastic scatters due to mass uncertainties.

It is known from operation of the apparatus in the SLAC experiment that some 40% of our triggers are due to b) and c) (see Appendix B). Folding this in with a), we can reasonably expect a trigger every 15-20 expansions of the bubble chamber.

IV. MATERIAL RESOURCES AND PERSONNEL

Essentially the entire spectrometer setup described above, except for the magnet, could be made available sometime toward the latter part of 1972. Prior to that time the Sigma-2 is committed to another NAL experiment.

We expect to take about 300K pictures in this experiment. Facilities to analyze these pictures exist at LRL (the FSD) and will soon be operational at Caltech where a POLLY-like system is nearing completion. We would expect that these pictures could be analyzed in from 6 to 9 months.

Software for the on-line and off-line analysis of the wire chamber data is already written and in use. We are presently setting up a program to extract the physics from our present experiment. This program should be completed by mid-1972.

The personnel from LRL and Caltech who will be involved in this experiment if approved include 6-8 Ph.D.'s and one or two graduate students for setting up and running the experiment. It is expected that the graduate students and perhaps 4 full-time Ph.D.'s will be involved in the data analysis.

V. REQUESTED RUNNING TIME

In order to satisfy the requirements of sufficient statistics to do an adequate analysis of the spin composition of the N^* system, we feel that an exposure of about 80 ev/μb is necessary. This corresponds, allowing for bubble chamber fiducial volume cuts (60% of total volume usable) and geometrical efficiencies, to 4.5×10^6 expansions of the chamber. This in turn takes about 3 months of data taking. In addition, we will require about a month to set up and a week of beam time to check out equipment.

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APPENDIX A : KINEMATICS AND MASS RESOLUTION

Lab Kinematics

For reactions which we will be studying

$$a + b \rightarrow c + d \tag{A-1}$$

(where $m_a = m_c$, $m_b = m_{proton}$ and m_d = recoil mass) it will be useful to have simple expressions giving the lab angle and momentum of particle c in terms of s, t, and m_d. For two-body reactions where all the masses are known, the kinematics are completely given by s and t, the squares of the CM energy and four-momentum-transfer respectively. For the reactions of interest the angles between the beam and particle c, θ_1 will be small and $E_a \simeq p_a$, $E_c \simeq p_c$, since $p_a >> m_a$, $p_c >> m_c$. With these approximations

$$s = (p_a + p_b)^2 \simeq 2\ m_b\ p_a \tag{A-2}$$

$$t = (p_a - p_c)^2 \simeq -\ p_a\ p_c\ \theta^2 \tag{A-3}$$

One gets an exact expression for E_c by realizing that

$$t = (p_b - p_d)^2 = m_b^2 + m_d^2 - 2\ m_p\ E_d$$

and

$$E_a + m_d = E_c + E_d$$

This gives

$$E_c = (s + t - m_a^2 - m_c^2)/2\ mb$$

or

$$p_c \approx (s + t - m_d^2)/d\ m_p \tag{A-4}$$

Missing Mass Resolution

The recoil mass is given by

$$m_d^2 = (p_a + p_b - p_c)^2$$

$$= m_a^2 + m_b^2 + m_a^2 + 2\ m_b\ (E_a - E_c) - 2\ E_a E_c + 2\ p_a\ p_c\ \cos\theta$$

The error is given by

$$\delta m_d = \frac{\delta m_d^2}{2m_d} = \frac{1}{2m_d}\left[\left(\frac{\partial m_d^2}{\partial p_a}\ \delta p_a\right)^2 + \left(\frac{\partial m_d^2}{\partial p_c}\ \delta p_c\right)^2 + \left(\frac{\partial m_a^2}{\partial \theta}\ \delta\theta\right)^2\right]^{1/2} \tag{A-5}$$

where

$$\frac{\partial m_a^2}{\partial p_a} \approx 2\ m_p - p_c\ \theta^2 \approx 2\ m_p \tag{A-5a}$$

$$\frac{\partial m_d^2}{\partial p_d} \approx 2\ m_p + p_a\ \theta^2 \approx 2\ m_p \tag{A-5b}$$

$$\frac{\partial m_d^2}{\partial \theta} \approx 2\ p_a\ p_c\ \theta \tag{A-5c}$$

In estimating errors the following assumptions were made:

a) Error in Measurement of p_c :

We have

$$p_c = \frac{0.03(B \cdot dL)}{\phi} \tag{A-6}$$

where B·dL is given in kGauss-meters, p in GeV/c and ϕ in radians. The angle ϕ measures the angle of bend in the magnet.

The error in the measurement of ϕ comes from the uncertainty in the angle of the lever arms of particle c's trajectory before and after the magnet and is given by

$$\delta\phi = \frac{2\delta x}{L}$$

where L is the length of the lever arm, δx is the positional accuracy of the wire chambers. Thus

$$p_c = \frac{2\delta x}{0.03(B \cdot dL)} \frac{p^2}{L} \tag{A-7}$$

b) <u>Error in Measurement of θ</u>:

There are two sources of error here, multiple scattering in the hydrogen and the measuring error.

$$(\delta\theta)_{scatt} = \frac{0.015}{p} \sqrt{\frac{d}{9.9}} \tag{A-8}$$

where d = .75m for the 30" chamber. The measurement error is

$$(\delta\theta)_{meas} = \frac{\sqrt{2}\,\delta x}{L} \tag{A-9}$$

where δx and L are defined as in (A-7). Thus

$$\delta\theta = \left[(\delta\theta_{meas})^2 + (\delta\theta_{scatt})^2\right]^{1/2} \tag{A-10}$$

APPENDIX B : PERFORMANCE CHARACTERISTICS OF THE DOWNSTREAM SPECTROMETER USED IN THE SLAC EXPERIMENT

We summarize here some of the relevant parameters of the experiment currently being run by this group at SLAC. The design of this experiment is very similar to the one being proposed for NAL.

Program (on-line) decision-making time.	$\leq$ 2 msec
Momentum measurement in the spectrometer for 14 GeV/c beam.	± 75 MeV
Fraction of the expansions which are photographed.	1 in 17
Contamination from elastic scattering.	20%
Fraction of pictures taken which have a good event (this includes contamination from elastics).	45%
Precision with which track can be located inside bubble chamber using spectrometer information.	± 1mm

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The specific goal of this experiment is to analyze the spin structure of the produced N^* system to test out various selection rules which have been conjectured for these diffractive processes and to compare these results with those of the lower energy experiment. In particular we will be able to check to what extent the diffractive processes stay constant with increasing energy.

The goals of this experiment could be met with $\sim 4.5 \times 10^6$ expansions of the 30-in. bubble chamber yielding an effective exposure size of ~ 80 ev/μb.

This should require about 3 months of running time. We expect that our trigger will yield about 300K pictures which could be analyzed by the combined measuring facilities of the two institutions represented in this group in about 6-9 months. The equipment necessary to do the experiment (excluding the spectrometer magnet) already exists and could be moved to and set up at NAL with a minimum of effort.

The above exposure size matches that of the experiment currently being carried out at SLAC. It represents what we feel is an exposure which provides the statistical sensitivity to determine the selection rules. The results of the analysis of the present experiment, which should be available a year from now, should determine whether one might increase or reduce the size of the requested exposure.

II. PHYSICS JUSTIFICATION

Experimental studies of quasi-two-body processes at present energies show that there exist a class of reactions which show the following strong characteristics (refer to Figure 1):

1) the reactions occur with relatively large cross sections (~ 1 mb);
2) the cross sections appear to remain constant with increasing energy;
3) the cross sections show a strong exponential t behavior ($d\sigma/dt \sim e^{-At}$ where A is on the order of 10-4 $(GeV/c)^{-2}$);
4) the internal quantum numbers (e.g., baryon number, g-parity, I-spin) of particle a(b) are the same as those of c(d).

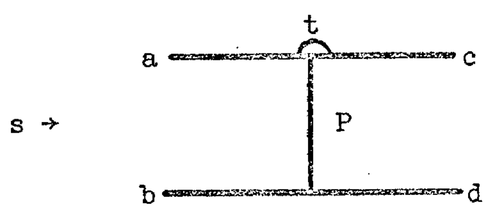

FIGURE 1

These processes, whose characteristics are similar to those of elastic scattering, are thought to proceed through Pomeron (0 quantum number exchange) exchange. They are referred to as diffractive processes. Examples of diffractive dissociation of the beam particle are the reactions

$$\pi p \to A_1 p \qquad \text{(II-1)}$$

and

$$\gamma p \to \rho^o p \qquad \text{(II-2)}$$

Our proposal is to study diffraction dissociation of the target particle giving rise to N^* ($I = \frac{1}{2}$) production.

The experimental and theoretical picture of diffractive processes is still quite unclear. Several selection rules, in addition to the internal quantum number selection rules, have been proposed. Morrison[1)] has suggested the empirical rule

$$\Delta P = (-1)^{\Delta J} \qquad \text{(II-3)}$$

where ΔP and ΔJ are the change in the parity and spin between the produced and initial dissociating particle. In our case this would be the N^* and the proton respectively. Chou and Yang[2)] have suggested that if the product of the parities of the incoming and outgoing particles is odd, the cross section for scattering at t=0 is zero. Carlitz, Frautschi and Zweig have included in the list of internal quantum number selection rules the conjecture that the SU(6) character[3)] is also preserved in diffraction scattering.

There have also been suggestions that there are selection rules which restrict the change in spin direction between initial and final particles, where by initial here we mean the dissociating particle and the final particle is the produced particle. For example, a study of ρ^0 photoproduction[4)] indicates that s-channel helicity is conserved. That is, in this example of diffractive scattering, the spin projection along the direction of motion of the initial and final particle is preserved. However a recent study of A_1 production indicates that it is t-channel helicity which is conserved[5)] In this case the projection along the initial particle direction in the Gottfried-Jackson frame[6)] is conserved. The corresponding tests for N^* production have not yet been made.

In order to study and test these various conjectures for reaction (I-1) what is necessary is a systematic high statistics study of the spin composition of the produced N^* system[7]. Up to now, the data which allow one to look at the decays of the produced N^* are bare bubble chamber experiments which suffer from very low statistics (2-3 ev/μb). On the other hand the high statistics missing mass experiments[8], while providing information on the energy and t-dependence of N^* production do not allow one to study the spin composition of the N^* system.

The group proposing this experiment is presently engaged in a similar one at the Stanford Linear Accelerator Center. The goal of that experiment is to obtain a high statistics sample of bubble chamber photographs of diffractive scattering, thus allowing a study of the decay characteristics of the N^*. In order to keep the number of photographs small while taking an effectively large exposure (300K pictures, 100 ev/μb) the 40-in. chamber at SLAC is being operated in a triggered mode. The energy of the incident π^- beam in that experiment is 14 GeV/c.

Motivation for going to the highest energy (consistent with good resolution and acceptance using present equipment) is very strong. The present diffractive data indicate that gross features remain unchanged with energy. A comparison of the lower energy detailed spin analysis with a similar study at significantly higher energy would thus be valuable. Another point has to do with the contribution of the OPE amplitude at lower energies. The OPE contribution complicates somewhat the spin analysis in the lower energy experiment[7]. At an energy of 50 GeV/c, the contribution of this amplitude relative to diffractive scattering is down by a factor of 10 compared with the lower energy (14 GeV/c case) owing to the p_{LAB}^{-2} fall-off of the OPE amplitude. Moreover, as the overall center of mass energy increases, the kinematics separate OPE reactions like $\pi N \to \rho N$ and $\pi N \to \rho\Delta$ from the two and four prongs, respectively, resulting from diffractive N^* production.